SOUTH CAROLINA IRRIGATION GUIDE

CHAPTER 1. INTRODUCTION

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CHAPTER 1. INTRODUCTION

PURPOSE AND OBJECTIVE

This irrigation guide is for the entire state of South Carolina. The guide has been prepared by the Soil Conservation Service with assistance from other Federal and State Agencies for use by trained personnel in planning and designing irrigation systems and use in irrigation water management. The basic data will assure the irrigator that the irrigation system will be capable of supplying the quality and quantity of water needed by plants for optimum production and that with proper seasonal adjustments, irrigation water can be applied efficiently. Recommendations included in this guide are for the most common types of irrigation systems now used in the state.

Some basic data for economic evaluation are included. However, it must be kept in mind that the economics of irrigation are usually an individual field or farm determination in which various other factors may enter.

Many principles of conservation irrigation are basic for other aspects of planning such as drainage and erosion control. The guide should form a sound basis for collecting and evaluating needed additional information.

RAINFALL IN SOUTH CAROLINA

AVERAGE RAINFALL

The average annual rainfall of the Southeast River Basins is about 50 inches. The United States average is about 30 inches. Figure 1-1 shows the average annual rainfall over South Carolina.

Based on 90 years of record, the mean is about 48 inches with extremes ranging from 33 inches in 1954 to 72 inches in 1964.

SOUTH CAROLINA

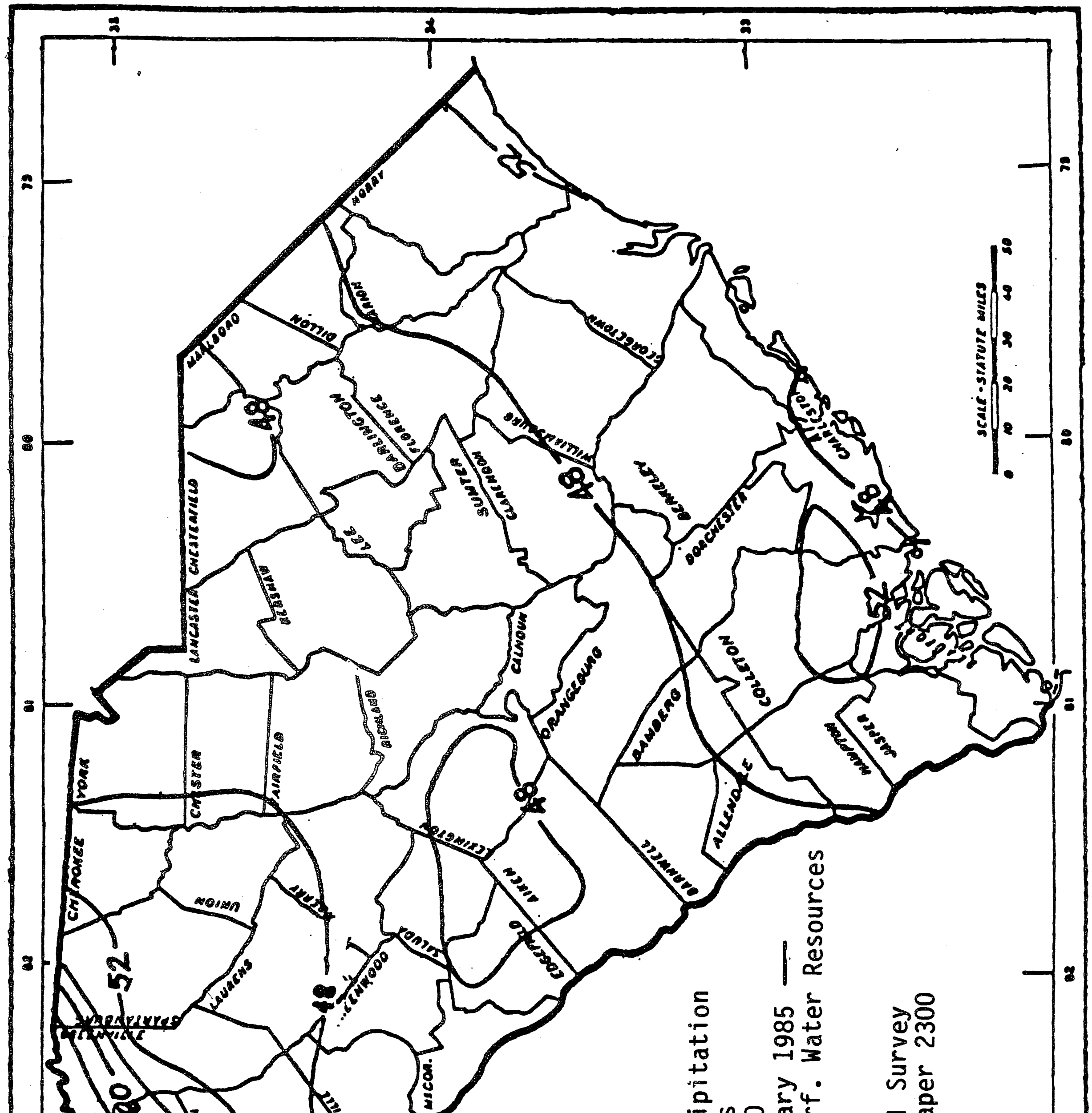


Figure 1-1

SEASONAL DISTRIBUTION OF RAINFALL

Figure 1-2 shows the normal seasonal distribution of monthly rainfall for three climatic zones in South Carolina for the period 1951-1980 (see ch. 4 for zone boundaries).

Season	Normal Precipitation (Inches) Zone 1	Zone 2	Zone 3
Winter 1/	12.87	11.07	10.47
Spring 2/	13.93	11.98	11.42
Summer 3/	12.77	15.24	17.04
Fall 4/	10.21	9.02	9.88
Annual	49.78	47.31	48.81

1/ December, January, February
2/ March, April, May
3/ June, July, August
4/ September, October, November

Figure 1-2

In general, the rainfall is fairly well distributed throughout an average year, with most of the rain occurring during the growing season. Variations in seasonal and especially monthly rainfall from year to year are often significant. For example, the standard deviation of the normal monthly rainfall varies from about 40 to 55 percent. This means that about 32 percent of monthly rainfall measurements would vary more than 40 to 55 percent from the normal.

The summer peak, which is more prominent in the southeastern portion of the state, is a product of thunderstorms which produce a large portion of the summer rainfall. The climatic effect of hurricane rainfall is relatively insignificant because hurricanes occur infrequently at any location, and their aggregate rainfall is small compared with the scattered, though more frequent, thunderstorm rainfall.

YEAR-TO-YEAR VARIABILITY OF RAINFALL

The variation in total annual rainfall from year to year can be large. Extremes of 50 percent more and 50 percent less than average have occurred in most records. Significantly, the annual rainfall is rarely less than the United States average of 30 inches.

AVERAGE AND SEASONAL DISTRIBUTION

Figure 1-3 shows the average daily temperature in degrees Fahrenheit for 3 climatic zones in South Carolina (see chapter 4 for zone boundaries). In general, the average daily temperature at the height of summer is slightly below 80°. July temperatures averaging about 75° are typical of most of the United States.

	Average Daily Temperatures (°F)		
Season	Zone 1	Zone 2	Zone 3
Winter 1/	44.0	46.5	47.6
Spring 2/	61.1	63.4	63.6
Summer 3/	77.7	79.1	79.0
Fall 4/	62.3	64.2	65.0

1/ December, January, February
2/ March, April, May
3/ June, July, August
4/ September, October, November

Figure 1-3

In January, the average daily temperature in South Carolina is about 40°F in the mountains, 45° over much of the Piedmont province, and 50° over much of the Coastal Plain.

DAILY RANGE OF TEMPERATURE

The average daily temperature range is about 20°F, with the minimum usually at sunrise and the maximum usually early in the afternoon. Exceptions to this regime occur, of course, with a frontal passage and a change in air mass; strong wind and mixing; and dense clouds. With unusually long duration of cloudiness or with dense coulds, the daily temperature range may be less than 10°; and with clear skies, dry air, and light wind the range frequently exceeds 30°.

On an average January day the temperature rises to more than 50°F in the mountains, the low 60's in the central part of the state, and reaches 70° in the extreme southeast part. the minimum temperature during an average January day is 30° in the mountains, 40° in the central part, and nearly 50° in the extreme southern portion.

In July the average daily maximum temperature is about 90°F over most of South Carolina and somewhat less in the mountains. During a typical July night the temperature falls to about 70° over most of the state. In the mountains, the minimum is about 60°, and the coast is in the low 70's.

GROWING SEASON AND DEGREE DAYS

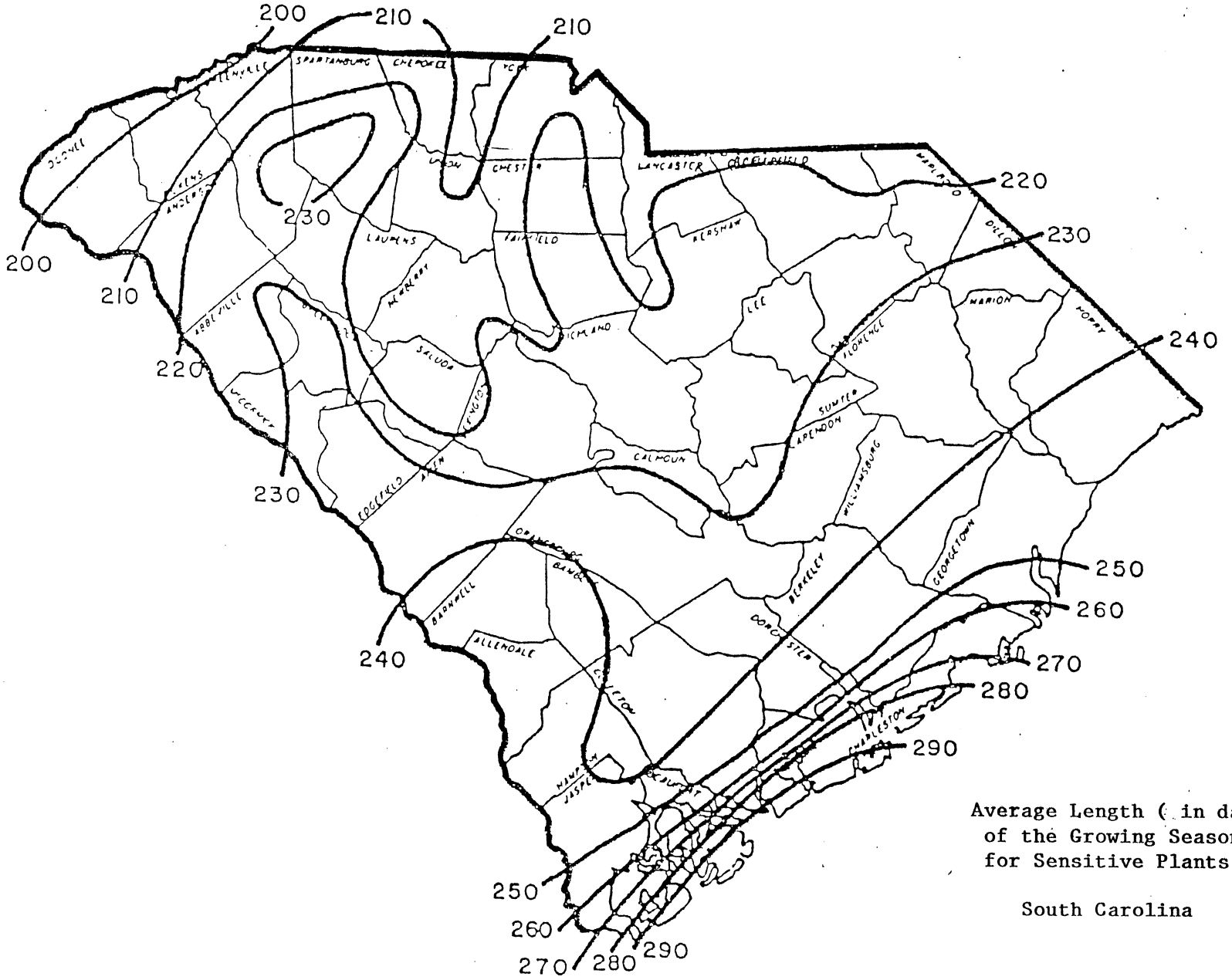
Growing season is defined as the period between the last occurrence in spring and the first occurrence in autumn of temperatures below a given base. This base is different for different plants, some being much hardier than others. Tomatoes are damaged at temperatures below 32°F, wheras peas and cabbage can withstand temperatures as low as 24° for brief periods. Figure 1-4 shows the average frost-free period or length of growing season for sensitive plants. The number of days range from 200 in the mountains to 290 in the extreme southeast, with most of the state having about 230. These values vary, of course, from year to year. In the north, the length of growing season is within about 20 days of the average two-thirds of the years, and in the south it is within about 30 days two-thirds of the years.

Figure 1-5 shows the average date of the last freeze in spring, and Figure 1-6 shows the average date of the first freeze in autumn. Both figures apply to sensitive plants. For hardy plants, the average growing season limits would be about 25 days earlier in spring and about 20 days later in autumn.

WIND

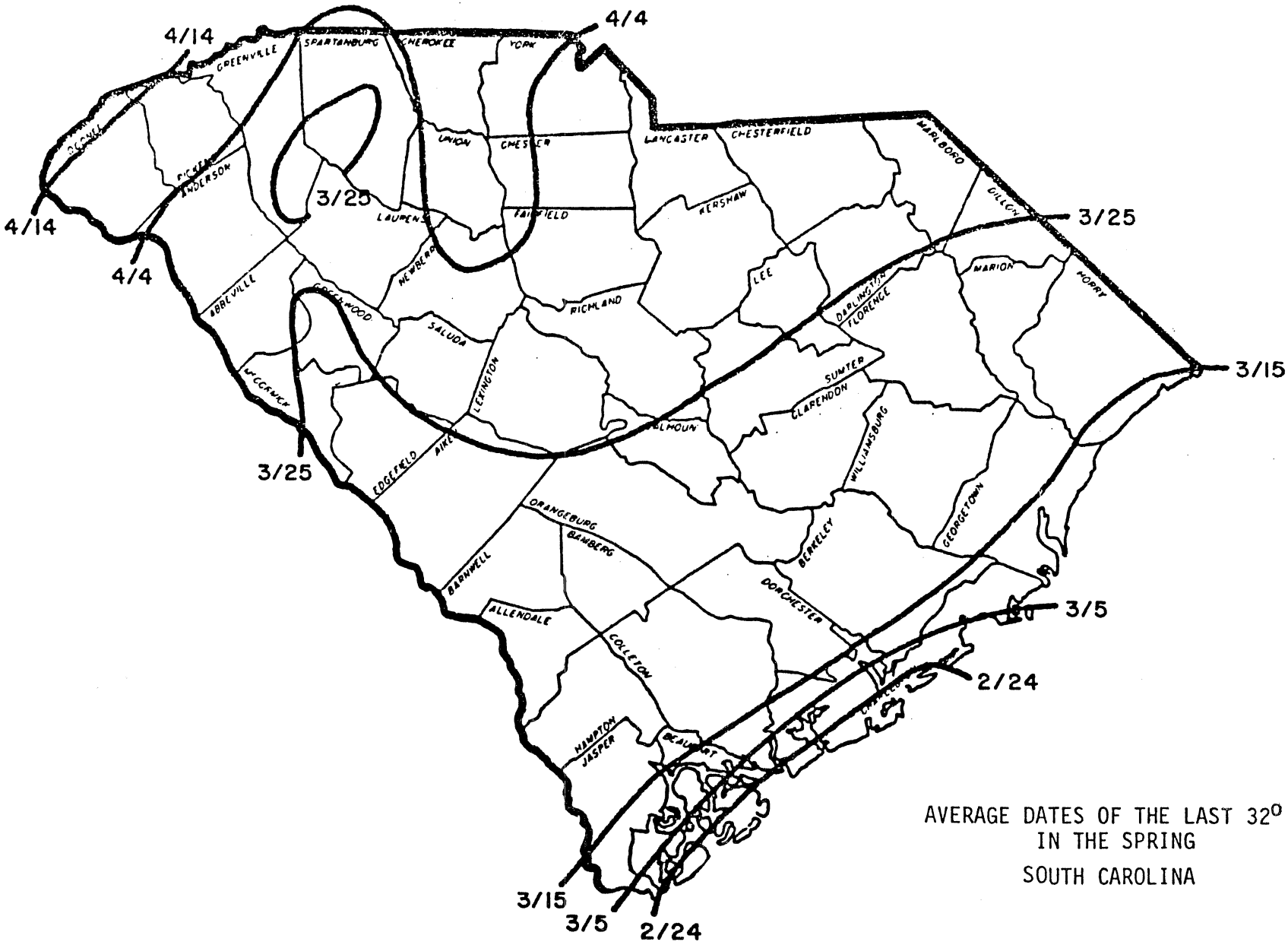
Winds are predominantly southwesterly and northeasterly over most land areas. Average wind speeds are 5 to 10 mph for the state.

Physiographic influences in South Carolina are important. Stations such as Charleston, which are near the open coast, have average wind speeds of 7 to 10 miles per hour; stations, such as Anderson, on ridges or plateaus, have average wind speeds of 8 to 10 miles per hour; and at relatively sheltered valley stations such as Columbia, the winds average 5 to 7 miles per hour.



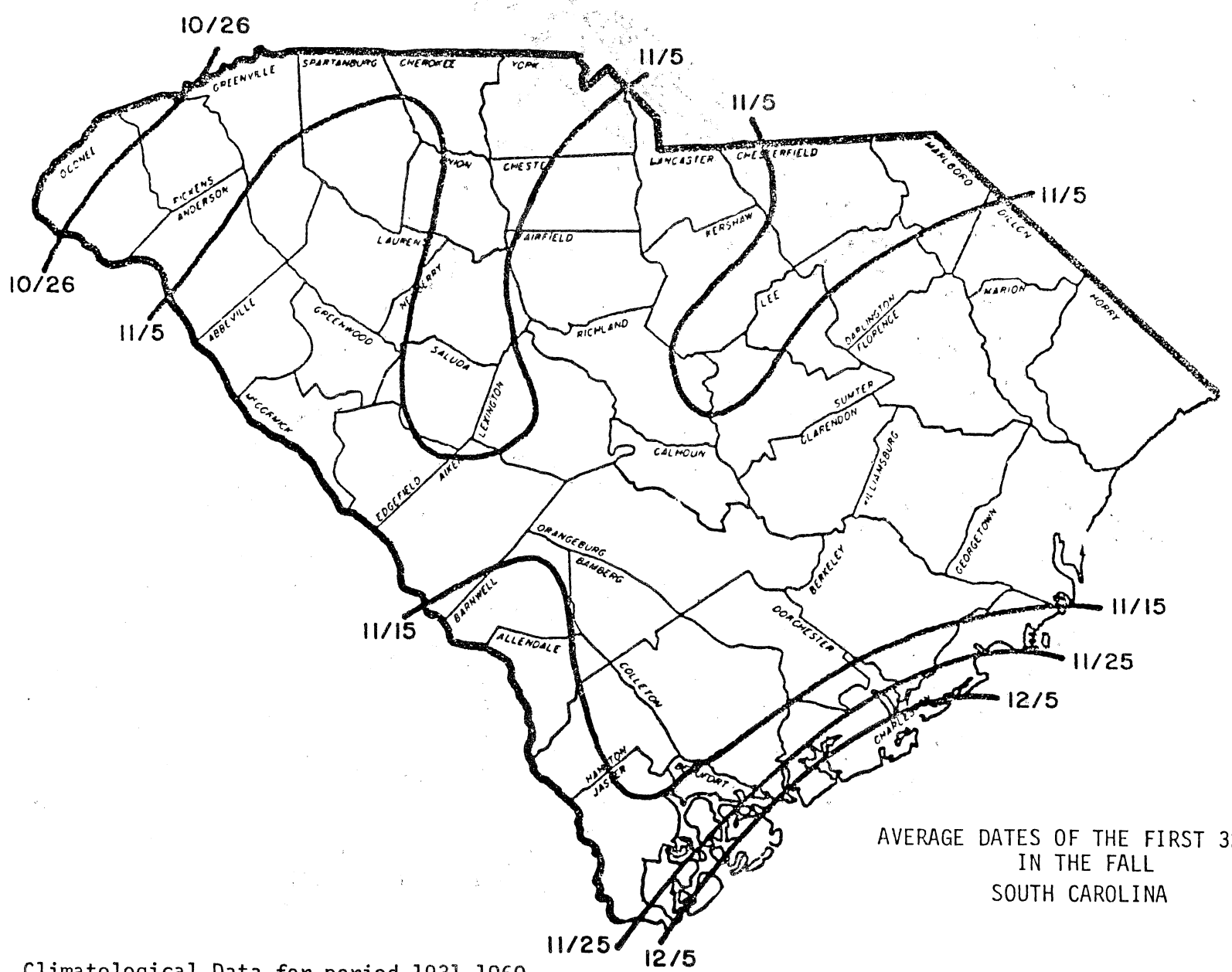
Source: S.C. Climatological Data for period 1931-1960

Figure I-4



Source: S.C. Climatological Data for period 1931-1960

Figure 1-5



AVERAGE DATES OF THE FIRST 32° F.
IN THE FALL
SOUTH CAROLINA

Source: S.C. Climatological Data for period 1931-1960

Figure 1-6
1-8

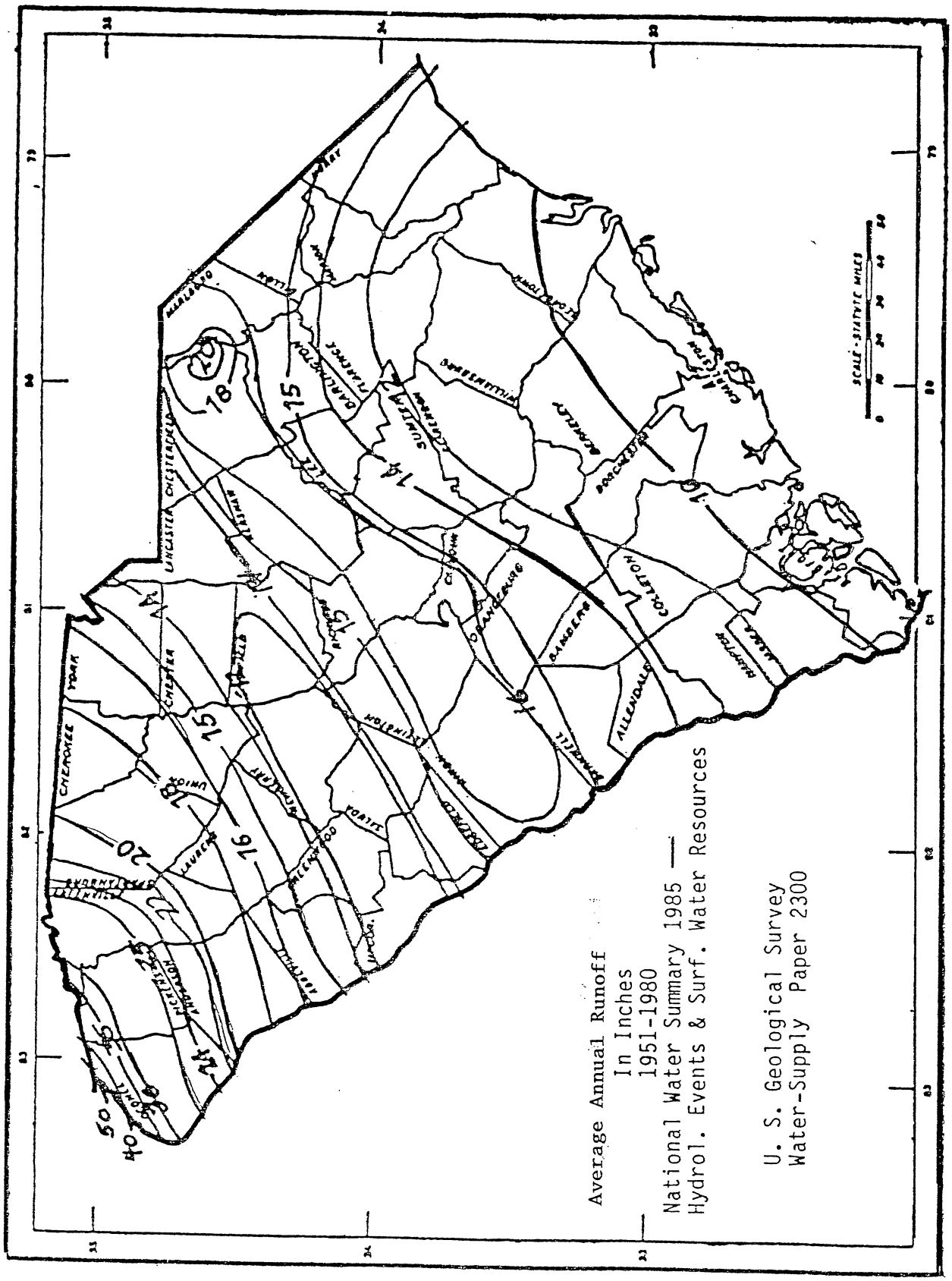

SOUTH CAROLINA
Average Annual Runoff
In Inches
1951-1980
National Water Summary 1985 —
Hydrol. Events & Surf. Water Resources
U. S. Geological Survey
Water-Supply Paper 2300

Figure 1-7

SURFACE WATER

AVERAGE STREAMFLOW

The average annual streamflow in South Carolina represents about 22 inches average depth over the State (U.S. Geological Survey, 1985), compared to the United States average of about 8 inches. The range of annual streamflow is from about 10 inches in the lower Coastal Plain and lower Piedmont to about 45 inches in the Blue Ridge (mountains) (figure 1-7)

SEASONAL DISTRIBUTION OF STREAMFLOW

Regardless of variations in the seasonal rainfall pattern, the average streamflow, except in certain coastal areas, is high in early spring and recedes to a low in late autumn. This average seasonal regime is typical even of most small streams in the rural areas. The summer rainfall peak does not ordinarily produce a summer runoff peak because summer showers usually fall on relatively dry soil and because much moisture is transpired by vegetation or evaporates directly to the air in summer, thus leaving relatively little contribution to runoff.

LOW FLOWS

Streams in the lower Coastal Plain and lower Piedmont normally have poorly-sustained base flows and some streams periodically go dry during late summer and fall. This is in contrast to the Blue Ridge province and upper Coastal Plain (figure 1-8, B) where base flows are well-sustained.

More information on low flows of streams in South Carolina may be obtained from the following publications of the South Carolina Water Resources Commission by Bloxham (1976, 1979, 1981).

Bloxham, W. M. 1979. Low-Flow Frequency and Flow Duration of South Carolina Streams. South Carolina Water Resources Commission, Report No. 11. 90 pp.

Bloxham, W. M. 1976. Low-Flow Characteristics of Streams in the Inner Coastal Plain of South Carolina. South Carolina Water Resources Commission, Report No. 5. 28 pp.

Bloxham, W. M. 1981. Low-Flow Characteristics of Ungaged Streams in the Piedmont and Lower Coastal Plain of South Carolina. South Carolina Water Resources Commission, Report No. 14. 48 pp.

WITHDRAWALS

The average surface water discharge from South Carolina is about 33 billion gallons per day (U.S. Geological Survey, 1985). Between 1970 and 1980, total offstream water use in South Carolina nearly doubled to 5,780 million gallons per day (Mgal/d). This amount is projected to increase to about 8,550 Mgal/d by the year 2020 (South Carolina Water Resources Commission, 1983).

WATER QUALITY

General

The quality of South Carolina's surface water is generally excellent and suitable for most uses. The water is soft and has a low buffering capacity. There are no known significant quality problems concerning irrigation of surface water.

Temperature

The natural temperature in large streams is near the average monthly air temperature. In smaller streams, day-to-day fluctuations in water temperature are greater than for the larger streams and in the smallest streams, hour-to-hour variations are evident with the daily range of temperature being nearly as great as for the nearby air.

Dissolved Solids and Acidity

The range of dissolved solids for surface water in South Carolina is from less than 15 to more than 100 mg/L with values generally ranging from 20 to 80 mg/L. The ph of surface water generally will be in the range from about 5.0 to 7.5 with alkalinity ranging from about 1 to 40 mg/L.

GROUND WATER

WATER-BEARING FORMATIONS (Aquifers)

The areal distribution of the principal aquifers in South Carolina are shown in figure 1-8. The Piedmont and Blue Ridge aquifers occur in alluvial deposits of sand and gravel; in weathered saprolite; and in joints, fractures and fault zones of cystalline bedrock.

The Coastal Plain aquifers occur in a wedge shaped area consisting of sand, clay and limestone sediments overlaying metamorphic and sedimentary rocks. The wedge, thickening from the Fall Line toward the coastline, can be divided into aquifers and confining units based on relative permeabilites, and other factors (figure 1-8, C) Water generally moves laterally within each aquifer with confining units inhibiting but not preventing vertical movement of water between aquifers. (Ancott and Speiran, 1984)

Ancott and Speiran, 1984. Ground Water Flow in the Coastal Plain Aquifers of South Carolina, U. S. Geological Survey.

WATER AVAILABILITY

In general, the Blue Ridge and Piedmont Provinces have limited ground water supplies because of their geology. The underlying igneous and metamorphic rock (overlain by a weathered surface) is dense and crystalline and water is available only in the thin soil mantle and fracture zones of the rock itself.

Within the Coastal Plain, thick sedimentary aquifers provide substantially greater supplies of generally good quality water. Ground water can be obtained nearly everywhere by drilling a well and pumping.

WELL DEPTHS

Most water is stored in the top several hundred feet in the Piedmont and Blue Ridge Provinces, thus well depths usually stay within this range. Wells in the Coastal Plains often produce adequate yields at depths less than 500 feet (ft) but it is not rare for depth to be 1000 ft or greater.

WELL YIELD AND WATER LEVELS

In the Piedmont and Blue Ridge, typical wells yield 10 to 30 gallons per minute (gpm) with water levels generally less than 100 ft but sometimes exceeding 200 ft from the ground surface. Water levels in most deep Coastal Plain wells (several hundred ft.) prior to development usually are within 50 ft. beneath the

surface and sometimes above land surface in the lower Coastal Plain due to artesian conditions. In upland areas of the upper Coastal Plain, water levels prior to development may be deeper than 200 feet. (personal communication, Gary Speiran, 1986)

Most large capacity wells in the Coastal Plain are screened in the Black Creek or the Middendorf (Tuscaloosa) Aquifer. Potential yields range from several hundred to greater than 2000 gpm. Little decline in water levels is being experienced except in heavily pumped areas of Florence, Myrtle Beach, and Savannah. Declines in the Florence area are reported to be greater than 100 ft. since 1930 for selected wells. (Ancott & Speiran, 1985a, 1985b)

After development, water levels in wells screened in the Black Creek and Middendorf aquifer are commonly in the range from 50 to more than 250 ft. from the soil surface at the pumping well. (personal communication, Gary Speiran, 1986) The actual water level at any particular well during pumping is dependent on many factors including static water level prior to pumping, permeability of in-place materials and the gravel pack or filter at the screened sections, the well screen itself, transmissibility of the aquifer, and the discharge of the well.

Screens or perforated casings are utilized in unconsolidated sand and gravel aquifers to allow water to enter the well and to stabilize the aquifer material. Consolidated rock aquifers often may be completed without perforated casing or screen. Due to the cost of screens, usually only the higher yielding zones are screened, resulting in some wells being multi-screened. Zones of poor quality water should not be screened if ample quantity of good quality water is available at different depths.

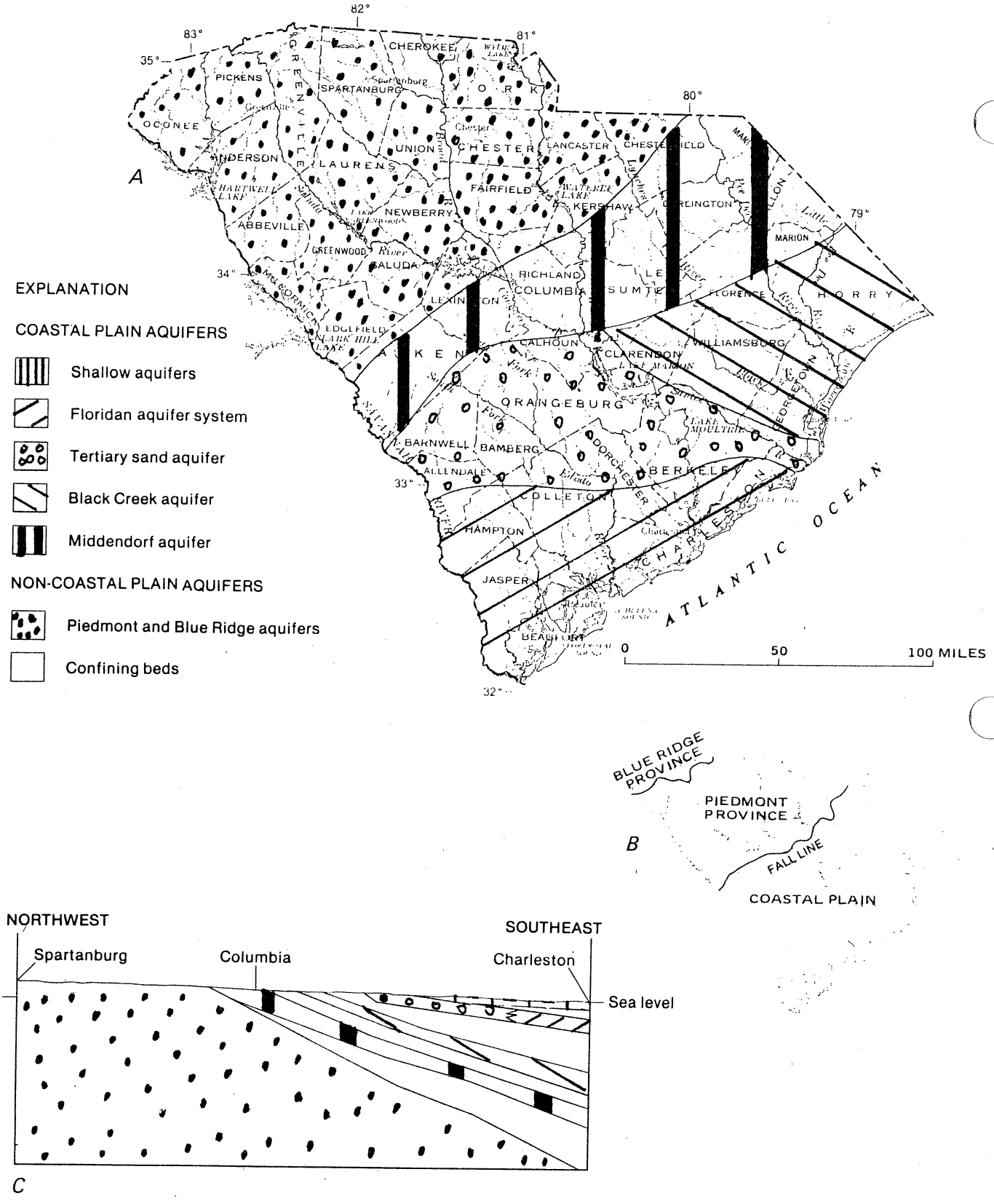


Figure 1-8. Principal aquifers in South Carolina. A, Delineations indicating the most widely used aquifers. B, Physiographic diagram and divisions. C, Generalized cross section. (See table 2 of the National Water Summary - South Carolina for a more detailed description of the aquifers. Sources: A, C, Compiled by W.R. Aucott from U.S. Geological Survey files. B, Fenneman, 1938; Raisz, 1954.)

For more information, see South Carolina Technical Note Engineering 2 (Geology) on file in SCS county offices, S.C. Water Resources Publications, or U.S. Geological Survey Reports as referenced.

Aucott and Speiran. 1984. Water Level Measurements for the Coastal Plain aquifers of South Carolina prior to development. U. S. Geological Survey Open-File Report 84-803.

Aucott, W. R. and G. K. Speiran. 1984a. Potentiometric surfaces of the Coastal Plain aquifers of South Carolina, prior to development. U. S. Geological Survey Water-Resources Investigations Report 84-4208.5 sheets.

Aucott, W. R. and G. K. Speiran. 1984b. Potentiometric surfaces for November 1982 and declines in the potentiometric surfaces between the period prior to development and November 1982 for the Coastal Plain aquifers of South Carolina. U. S. Geological Survey Water-Resources Investigations Report 84-4215.7 sheets.

WITHDRAWALS

The 1980 withdrawal of ground water in South Carolina was slightly less than 210 mgal/d (Lonon & Others, 1983). This is equivalent to about two-sevenths inch average depth per year over the southeastern half of the state. A question to be considered is what rate of withdrawal could be sustained. As indicated by water level declines in areas where ground water pumpage is greatest (Myrtle Beach, Florence, Sumter, and Savannah, withdrawals may be approaching maximum sustainable yields locally. In other areas of the Coastal Plain, ground water is relatively undeveloped thus significant increases in withdrawals over present rates should be sustainable in most situations.

Ground-water withdrawals for irrigation are seasonal, usually are spaced widely, and are located mostly in the upper part of the Coastal Plain where aquifer yields are large. Because of these conditions, declines in water levels due to irrigation are very localized and seasonal thus no deep permanent cones of depression have developed. (Lichtler & Aucott, Water Supply Paper 2275)

Lonon, G. E., Burnett, C. B., and Morris, H. J., 1983, Water use in South Carolina, 1980: South Carolina Water Resources Commission Report No. 138, 20 p.

Lichtler, W. F. and Aucott, W. R. S. C. Ground-Water Resources, National Water Summary, U. S. Geological Survey Water Supply Paper 2275, p 379-384.

WATER QUALITY

General

Ground water quality as related to irrigation is generally good to excellent in South Carolina. At points along the coast, salt-water intrusion is a problem; and inland there are scattered places where salinity or sulfur limit use. Probably the most widespread problem concerns acidity (alkalinity) and dissolved solids and their effect upon metal parts of irrigation systems. In the Middendorf aquifer along the coast, concentrations of boron of as little as 8 mg/L may cause problems with certain irrigation uses.

Temperature

In general, temperature of ground water is about the same as mean annual air temperature at the water table and increases to more than 100° F at depths greater than 2500 feet. Temperature of water from very shallow wells or from very small springs varies seasonably but temperature of water from deeper aquifers changes very little. Temperature of shallow ground water ranges from about 64 to 69° F in the Coastal Plain and slightly cooler north of the Fall Line to below 60° F in the mountains (Personal Communication, G. Patterson, USGS, Columbia, SC)

Dissolved Solids and Acidity

The ph and alkalinity increases going from the West toward the coast within the range from about 4.0 to 9.0 (ph) with alkalinity less than 1 to greater than 1,000 mg/L. Values of ph are generally between 6.0 and 8.6. (personal communication-Glenn Patterson, USGS, Columbia, SC) At the lower end of the pH range, (acid) damage may occur to well casings, screens, pumps, and the metal parts of the irrigation system. Both acidity and low total dissolved solids, which are known causes of corrosion, are recognized problems in several center pivot systems in Lee and Sumter Counties. Some steel pipes have been severely corroded and have failed after only two to five years use. Results of chemical testing, provided by the Water Resources Commission to irrigators, indicate the probable cause of deterioration of pipes in this area to be a combination of these two problems (acidity and low total dissolved solids). However, there may be some other contributing source not yet investigated.

At present, one recommended action for existing steel pipe systems is to inject lime containing adequate calcium carbonate to neutralize the acid and provide a substance that the water can dissolve instead of dissolving the pipes. The lime is normally injected on the discharge side of the pump. This slows down the attack and depending on the condition of the pipe, it may add many years of life to the system

(personal communication, L. Lagmon, Chemist, SC Water Resources Commission, Columbia, SC). The screen should be of fiberglass, high quality stainless steel, or other material resistant to attack.

The water source for the known problem sites is primarily the Tuscaloosa (Middendorf) aquifer. The suspect area is a strip along the fall line including the upper Coastal Plains from Augusta, Georgia, through Chesterfield, South Carolina. Future ground-water investigations to be conducted by the Water Resources Commission will provide additional data to better define the area and refine treatment procedures.

It is recommended that irrigators have their water supply analyzed to determine the water quality, whether surface or subsurface source is being used.

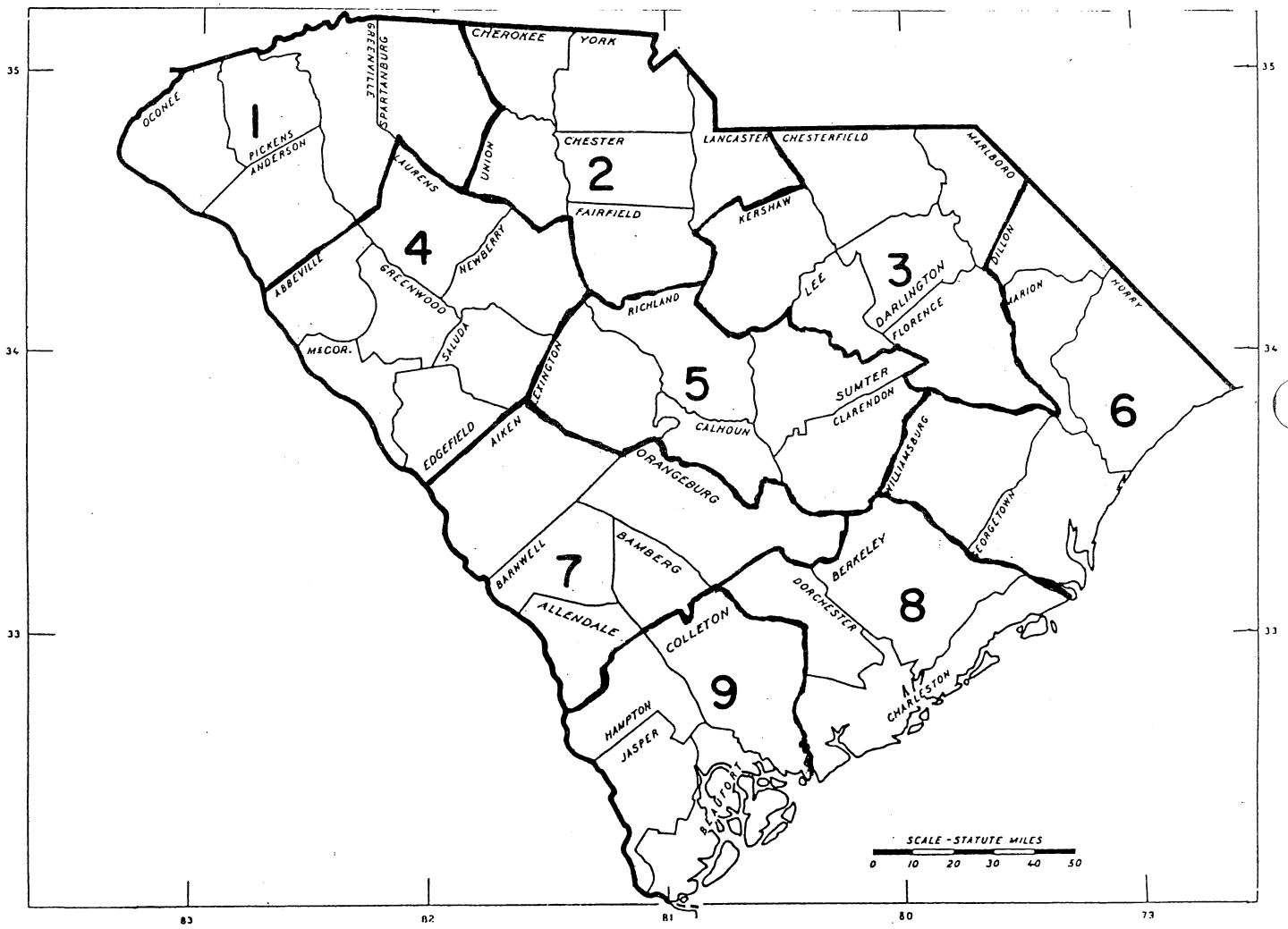
For new systems, a water quality analysis should be made at the test well stage. It is advisable to use PVC or other approved pipe when possible rather than steel pipe for sites where this problem is identified or is likely to develop. Otherwise, the owner should be prepared to replace damaged components or treat as needed for protection. The South Carolina Water Resources Commission currently will obtain samples, do the testing and provide recommendations for treatment on a request basis at no charge for agricultural use when the site is located within one of the Commission's study areas. The Geology-Hydrology divisions Ground-Water Project areas map is shown on Figure 1-9.

For specific information about water quality at a particular location, landowners should address inquiries to the following address:

Water Resources Commission
P. O. Box 4440
Columbia, South Carolina 29240
Phone: 758-2514

Figure 1-9. Ground-Water Project Areas - Water Resources Commission

No.	Name	No.	Name
1	Appalachia	6	Waccamaw
2	Catawba	7	Lower Savannah
3	Pee Dee	8	Trident
4	Upper Savannah	9	Low Country
5	Central Midlands		



Technical personnel are encourages to discuss the acidity and dissolved solid problems with irrigators to make them aware of the known potential problem areas and the need to have their water analyzed.

Sand and Minerals

When pumping from ponds, streams, or wells with suspended sand, the pump and irrigation equipment orifices need to be checked regularly for wear. Sand content does not have to be high enough to make the water unclear for it to cause severe wear. A good indication of pump or orifice wear is a reduction in system pressure at the usual operating speed and water level.

The hardness (mineral content) of the water can cause equipment problems due to mineral deposits closing orifices, freezing sprinklers and mineral encrustation in pipes.

Trickle Irrigation Concerns

Trickle irrigation systems with their small emitter openings and more intricate labyrinth-type internal structures are more easily clogged than other types of irrigation. Clogging seems to be less of a problem in those types of emitters through which the water moves at higher velocities.

Particulate matter and bacterial slimes are the usual causes of these clogging problems. Filtration will take care of the particulate matter problem, but with a high particulate matter content cleaning filters can become a problem.

A combination of chlorine and filters will control the bacteria problem. It should be used as a preventive rather than a corrective treatment, because it is very difficult to clean out systems once they are clogged. Chlorine should be metered according to need rather than just "dumped" into the system. Chlorine injection should result in a free residual chlorine level of 0.5 to 1.0 ppm at the end of the system. This level should be maintained for a period of 30-45 minutes and should be applied periodically depending on the quality of the water supply. (See appendix E of this guide for further information.)

Surface water may be suitable for trickle irrigation if chlorine is injected at the pump and a sand filter is used to trap the algae and particulate matter before they enter the lines and emitters.

Before installing a trickle irrigation system, the landowner should have tests run to determine the charactristics of the water. Important chemical characteristics include the following :

- ph
- Total concentration of soluble salts and the sodium absorption ratio (S.A.R.)
- Relative proportion of sodium to the other cations
- Bicarbonate concentration as related to the concentration of calcium and magnesium ions. (i.e., calcium and magnesium needs to be greater than or equal to the bicarbonate conc.)
- Concentration of toxic elements
- Total concentration of chlorides

WASTE WATER APPLICATIONS

Waste water includes water that contains waste from municipal waste treatment plains, industrial plants, food processing facilities, dairies, and livestock operations. This waste water will contain various amounts of nutrients, organic material, and possibly heavy metals.

These waste waters can be used for irrigation, but the amount of this waste water that can be applied and the crops to which it can be applied will be determined by its quality. Irrigation with waste water containing heavy metals is very restricted. The fertility balance of the soil should be maintained by supplementing the waste applications with appropriate commercial fertilizers.

Waste water can be very corrosive causing system life to be limited and maintenance increased. Also, consideration should be given to the solids content of waste water. Large orifices are needed to pass the larger solids without clogging. A pump that chops up the solids may be required, depending on orifice and solid sizes.

Water containing human or animal waste should not be applied to crops that are consumed raw by humans.

For more information on irrigating with agricultural waste see Engineering Standards and Specifications Code 633 - Waste Utilization, the Agricultural Waste Management Field Manual, and Animal Waste Utilization on Cropland and Pastureland (USDA Utilization Research Report No. 6).